"REVIEW OF POULTRY AND DAIRY PRODUCTS ON NON TYPHOID SALMONELLA AND ITS ANTIBIOTIC RESISTANCE IN ETHIOPIA"

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ABSTRACT

Non-typhoidal salmonellosis is an important zoonotic ailment caused by the genus Salmonella which constitutes a major public health burden and represents a significant cost in many countries. Currently, at a global level, the main sources of infection for humans are foods of animal origin particularly meat, poultry, egg, milk and milk products are plays great role to be the primary source of human salmonellosis. Moreover, antimicrobial resistance in non-typhoidal Salmonella is considered one of the major public health threats related with food-animal production, including the poultry and dairy product, which is an additional concern in the management of salmonellosis. In Ethiopia, despite attempts to study prevalence of Salmonella mainly in poultry and beef, the status in milk and milk products is still unknown. The sixty-eight World Health Assembly in May 2015, the World Health Assembly endorsed a global action plan to tackle antimicrobial resistance. The goal of the global action plan is to ensure the continuity of successful treatment and prevention of infectious diseases with effective and safe medicine. A number of issues have been raised to help in containing antimicrobial resistance, including, improving awareness and understanding of antimicrobial resistance, strengthening knowledge through surveillance and research, reducing the incidence of infection, optimizing the use of antimicrobial agents and developing the economic case for sustainable investment that takes into account the needs of all countries, and the need for increasing investment in new medicines, diagnostic tools and vaccine. In recognition of such efforts, international partners such as the WHO, FAO and World Organization for animal health and the national partners are engaged in set of activities, such as, improving national awareness and understanding of antimicrobial resistance through public communication programmes that target the different audiences in human health, animal health and agricultural practices. In Ethiopia, there is no Salmonella serotype and antimicrobial resistance surveillance and monitoring system, therefore the available information are fragmented and made available through individual publications. One study, conducted on chicken and different chicken products in Ethiopia indicated the presence of different serotypes of Salmonella. The purpose of this review is to provide an overview of the role of poultry and dairy product on nontyphoidal salmonella and its antibiotic resistance in Ethiopia.

Keywords: - Non Typhoid Salmonella, Antibiotic Resistance, poultry product, Dairy product

1. INTRODUCTION

Salmonella is a leading cause of food borne illness (WHO, 1988; White et al., 2001). Globally, more than 93 million cases of gastroenteritis are caused by non typhoidal Salmonella with 155,000 deaths each year. Of these cases, 80.3 million cases were estimated to be food borne. Non-typhoidal fever, which is caused mainly by Salmonella typhimurium and Salmonella enteritidis, continues to be a major problem in developing countries. Gastroenteritis is the most common manifestation of Salmonella infection worldwide, followed by bacteraemia and enteric fever (Majowicz et al., 2010).

Non-typhoidal salmonella is an important zoonotic ailment caused by the genus *Salmonella* which constitutes a major public health burden and represents a significant cost in many countries. Foods of animal origin particularly meat, poultry, egg, milk and milk products are considered to be the primary source of human salmonellosis (Acha and Szyfers, 2001). In general, food animals such as swine, poultry and cattle are the prime sources of *Salmonella* infections. The major dissemination routes of the pathogens involve trade in animals and uncooked animal food products. The slaughtering process of food animals at abattoirs is considered one of the important sources of organ and carcass contamination with *Salmonella* (Gillespie *et al.*, 2005).

Salmonellosis takes a healthy tool in human life and suffering, particularly among infants and children, the elderly and other susceptible persons particularly in developing countries where most food industries are not well aware of food safety issues and knowledge of modern technologies. Good Manufacturing Practices, hygiene, Hazard Analysis Critical Control Point systems and quality control are often limited or absent in such countries. Cold storage facilities are inadequate and quality of water used for food processing may not be suitable. The vast numbers of labor that handle food in factories, as well as on farms are illiterate and untrained. In such countries lack of information leads to lack of appreciation of health significance of unsafe food (Van der Venter, 1999).

Amongst Salmonella species, antimicrobial resistance is a well confirmed phenomenon and antimicrobial-resistant Salmonella are increasingly associated with the use of antimicrobial agents. Antimicrobials are substances that have significantly contributed to the prevention and treatment of infectious diseases in humans, as well as too many animal species. However, the excess or overuse and misuse of antimicrobials can generate genomic selective pressures to enable microbes to adapt and acquire resistance (Yang et al., 2010; Mengistu et al., 2014). Ultimately, increases in bacterial antimicrobial resistance pose a considerable threat to public health, especially for vulnerable populations, including young children (Shea, 2003), the elderly and immune-compromised individuals (Hitti and Wolff, 2005).

There have been studies conducted in Ethiopia on salmonellosis which suggest an increase in the antimicrobial resistance of *Salmonella* to commonly used antimicrobials in both public health and veterinary sectors (Mache, 2002; Molla *et al.*, 2003; Alemayehu *et al.*, 2004; Argaw *et al.*, 2007; Zewdu, 2008; Beyene *et al.*, 2011; Sibhat *et al.*, 2011; Liyuwork *et al.*, 2013; Abebe *et al.*, 2014). The purpose of this review is to provide an overview of the role of poultry and dairy product non typhoidal salmonella and its antibiotic resistance in Ethiopia.

2. LITERATURE REVIEW

2.1 General characteristics of Salmonella

Salmonella make up a large genus of gram-negative bacilli within the family Enterobacteriaceae and it constitute a genus of more than 2300 serotypes that are highly adapted for growth in both humans and animals and that cause a wide spectrum of disease. Members

of the genus *Salmonella* are ubiquitous pathogens found in humans and livestock, wild animals, reptiles, birds, insects and can multiply under various environmental conditions outside the living hosts. *Salmonella*e are gram-negative, non-spore forming, facultative anaerobic bacilli, and 2 to 3 by 0.4 to 0.6 µm in size (Getenet, 2008). They do not require sodium chloride for growth, but can grow in the presence of 0.4 to 4%. Most *Salmonella* serotypes grow at temperature range of 5 to 47°C with optimum temperature of 35 to 37°C but some can grow at temperature as low as 2 to 4°C or as high as 54°C. They are sensitive to heat and often killed at temperature of 70°C or above. *Salmonella* grow in a pH range of 4 to 9 with the optimum between 6.5 and 7.5. They require high water activity (aw) between 0.99 and 0.94 (pure water aw=1.0) yet can survive at water activity less than 0.2 such as in dried foods. Complete inhibition of growth occurs at temperatures less than 7°C, pH less than 3.8 or water activity less than 0.94 (Pui *et al.*, 2011).

2.2 Classification and nomenclature of Salmonella

Salmonella was first discovered and isolated from the intestines of pigs infected with classical swine fever, by Theobald Smith in 1855. The bacterial strain was named after Dr Daniel Elmer Salmon, an American pathologist who worked with Smith. The nomenclature of Salmonella is controversial and still evolving. Currently, the Centers for Disease Control and Prevention (CDC) use the nomenclatural system of Salmonella recommended by the World Health Organization (WHO) Collaborating Centre (Popoff et al. 2003).

According to this system, the genus *Salmonella* is classified into two species, *Salmonella enterica* (type species) and *Salmonella bongori*, based on differences in their 16S rRNA sequence analysis. The type species, *S. enterica*, can be further classified into six subspecies based on their genomic relatedness and biochemical properties (Reeves *et al.*, **1989**).

The subspecies are denoted with roman numerals: I, S. enterica subsp. enterica; II, S. enterica subsp. salamae; IIIa, S. enterica subsp. arizonae; IIIb, S. enterica subsp. diarizonae; IV, S. enterica subsp. houtenae; and VI, S. enterica subsp. indica. Among all the subspecies of Salmonella, S. enterica subsp. enterica (I) is found predominantly in mammals and contributes approximately 99% of Salmonella infections in humans and warm-blooded animals. In contrast, the other five Salmonella subspecies and S. bongori are found mainly in the environment and also in cold-blooded animals, and hence are rare in humans (Brenner et al., 2000).

In addition to the classification of subspecies based on phylogeny, Kauffman and White developed a scheme to further classify *Salmonella* by serotype based on three major antigenic determinants: somatic (O), capsular (K) and flagellar (H). The heat-stable somatic O antigen is the oligosaccharide component of lipopolysaccharide located at the outer bacterial membrane. A specific serotype of *Salmonella* can express more than one O antigen on its surface (Hu & Kopecko., 2003).

The heat-labile H antigens are found in the bacterial flagella and are involved in the activation of host immune responses. Most *Salmonella* spp. contain two distinct genes that encode for the flagellar proteins; these bacteria have the special ability of expressing only one protein at a time and are, therefore, called diphasic (phase I and II). Each serotype expresses specific phase I H antigens which are responsible for its immunological identity, whereas phase II antigens are non-specific antigens that can be shared by many serotypes (McQuiston *et al*, 2008). The surface K antigens are heat-sensitive polysaccharides located at the bacterial capsular surface and are the least common antigens found in the serotypes of *Salmonella*. Virulence (VI) antigens, a special subtype of K antigen, are found only in three pathogenic serotypes: Paratyphi C, Dublin and Typhi. A formal identification of a specific serotype can be carried out by comprehensive serotyping of all the antigenic determinants of the bacterium. However, most clinical laboratories prefer to conduct simple agglutination reactions to

antibodies or antisera specific to the somatic O antigens with the intention of grouping Salmonellae into six serogroups, designated A, B, C1, C2, D and E. This grouping system provides valuable information for epidemiological studies and allows genus identification of *Salmonella* infections (Wattiau *et al*, 2011).

To date, over 2500 serotypes have been identified; more than 50% of these serotypes belong to *S. enterica* subsp. *enterica*, which accounts for most of the *Salmonella* infections in humans (Guibourdenche *et al*, 2010). The term 'serovar', which is synonymous to serotype, is commonly used in the literature. Although the species name '*Salmonella enterica*' has been adopted by the CDC and WHO for years, it has not been accepted officially by the Judicial Commission. Therefore, the naming of a particular *Salmonella* serotype usually omits the subspecies; *Salmonella enteric* subspecies *enterica* serotype Typhi, for example, is shortened to *Salmonella* ser. Typhi or *S.* Typhi in the literature (Brenner *et al*, 2000).

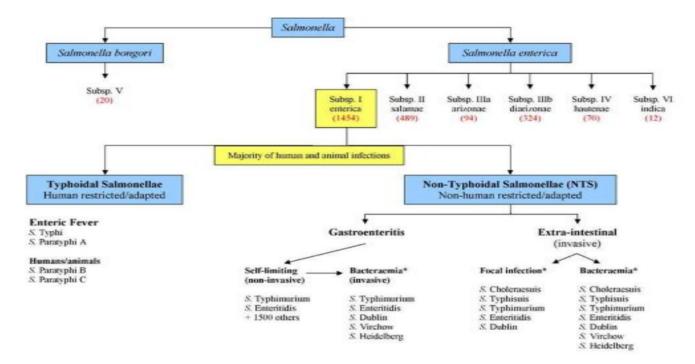


Figure 1. Classification and Nomenclature within the genus of *Salmonella* (Adapted from Langridge *et al.* 2008)

2.3 Epidemiology of non-typhoidal Salmonella

Salmonella serovar other than those causing typhoid or typhoid-like in humans are referred to as Non-typhoidal Salmonella (NTS). This group of serovars, for example, Salmonella serovar Typhimurium and Salmonella serovar Enteritidis, can infect a wide range of hosts, from insects to reptiles, birds and mammals. The global incidence of food borne infections has markedly increased, with nearly a quarter of the population at a high risk of illnesses (Oliver et al., 2005). Food borne illnesses occur ubiquitously along the globe. On a global scale, food borne and waterborne diarrhoeal diseases kill about 2.2 million people, including 1.9 million children annually (Min and Hussain, 2014).

Non-typhoidal *Salmonella* (NTS), an aetiological agent of non-typhoidal salmonellosis, is considered as one of the three top food borne bacterial pathogens worldwide (Newell *et al.*, 2010). Whereas non-

^{*}Salmonella categories not typically associated with foodborne disease are denoted with asterisks.

typhoidal salmonellosis is a disease of worldwide distribution; in contrast, the typhoidal salmonellosis is vastly distributed in low-income countries than the high-income countries (Tassew *et al.*, 2010; Mogasale *et al.*, 2014). The NTS is one of the most important food borne pathogens of public health significance (Scallan *et al.*, 2011). The NTS can colonize all warm and cold-blooded animals, including humans, and in addition, can cause most of the zoonotic infections in humans (Yan *et al.*, 2004).

Most of non-typhoidal salmonellosis in human is associated with various serotypes of *S. enterica* subspp, *enterica*. The NTS serotypes have broad host range including food animals and humans (Weinberger and Keller, 2005). Food of animal origin is identified as the main vehicle of transmission of public health important NTS serotypes to humans (Li *et al.*, 2013; Ahmed and Shimamoto, 2014). In addition, food animals with subclinical infection constitute a vast reservoir for disease (Gomez, *et al.*, 1997). So, human salmonellosis is mostly food borne and is contracted through consumption of contaminated food of animal origin such as meat, milk, poultry and eggs (Thong and Modarressi, 2011).

Non-typhoidal salmonellosis in humans may occur as an acute, self-limiting gastroenteritis or as systemic infection characterized by septicaemia and extra intestinal focal infections. The gastrointestinal form is often referred to as food poisoning syndrome (Edge worth, 2005; DuPont, 2009). The course and outcome of the infection in humans are dependent on a variety of factors including the immune status of the host, inoculating dose, and genetic background of both host and infecting organism (Cammie and Miller, 2000).

All *Salmonella* serotypes are presumably pathogenic to humans (Forshell and Wierup, 2006). Children, the elderly and immune-compromised individuals are the high risk groups with case fatality rates of 38% in children (Walsh *et al.*, 2000) and 47% in the elderly (Gordon *et al.*, 2002) were recorded. Human non-typhoidal salmonellosis disease syndromes range from asymptomatic colonization to severe extra-intestinal illnesses, such as meningitis, septic arthritis and osteomyelitis (Graham *et al.*, 2000). The high case fatality of extra-intestinal non typhoidal salmonellosis with meningitis is reported in Malawians as 52% in children and 80% in adults (Molyneux *et al.*, 2009), and a 100% case fatality in children in Tanzania (Vaagland *et al.*, 2004). Moreover, another study conducted in sub Saharan Africa by Kariuki *et al.* (2002) reported the multi-drug resistant (MDR) *S.* Typhimurium as the most predominant cause of bacteraemia in children.

2.4 Mode of transmission

Salmonella infection appears to be one of the most common examples of an enteric disease that is transmitted from animals to humans. The transmission occurs both through food products, such as meat, dairy products, and eggs, and by direct contact between animals and humans through the fecal-oral route (Olsvik, et al., 1985). Foodborne salmonellosis often follows consumption of contaminated animal products such as raw meat, poultry and eggs. Not washing fresh fruits and vegetables before eating them, as well as not thoroughly cleaning work surfaces used to prepare raw meat and other foods in the kitchen can also be source of Salmonella. Food can also be contaminated by food handlers who do not thoroughly wash their hands with soap after handling raw meat or after using the bathroom (WHO, 1989).

Salmonella infections are primarily of foodborne origin but can also occur through contact with infected animals, humans, other feces (Rounds *et al.*, 2010). The main mode of transmission is from food products contaminated with animal products or waste most commonly eggs and poultry but also

undercooked meat, unpasteurized dairy products, seafood, and fresh produced. *S. enteritidis* associated with chicken eggs is emerging as a major cause of foodborne disease.

2.5 Pathogenesis and virulence genes of NT Salmonella

The severity of Salmonella infections in humans varies depending on the serotype involved and the status of the human host. Children below the age of 5 vears, people and patients with immunosuppression are more susceptible to Salmonella infection than healthy individuals. Almost all strains of Salmonella are pathogenic as they have the ability to invade, replicate and survive in human host cells, resulting in potentially fatal disease. Salmonella displays a remarkable characteristic during its invasion of non-phagocytic human host cells (Hansen wester et al., 2002) whereby it actually induces its own phagocytosis in order to gain access to the host cell.

Salmonella spp. has selective potentials to invade and persist in host cells and they are well adapted to intracellular lifestyle (Lopez et al., 2012). Their ability to colonize macrophages and other immune cells is considered vital in establishing the infection in the host. This property has been genetically linked to virulence as mutants are unable to survive in such cells; in general, and they have a reduced or no ability of causing infection (Fields et al., 1986). Previous studies have reported on a large number of genes encoding virulence factors and the role they play in Salmonella pathogenesis. Most of these genes are in close contact to each other in the bacteria genome. These genes required for Salmonella virulence are found on the chromosome and on plasmids common to many Salmonella serotypes. Most are encoded within pathogenicity islands (Groisman and Ochman, 1996).

The genome of S. enterica is reported to harbor over 100 essential genes that have been implicated for Salmonella virulence (McClelland et al., 2001). These virulence-associated genes can be horizontally transmitted between S. enterica spp., and a number of regions (loci) harbouring multiple virulence (pathogenicity genes) called Pathogenicity Islands (PIs) have been reported in Salmonella spp. Salmonella pathogenicity islands are defined as large gene cassettes within the Salmonella chromosome and the plasmid that encode for genetic determinants responsible for establishing specific interactions between the host and Salmonella spp. Salmonella pathogenicity islands (SPIs) are acquired by horizontal transfer from phages plasmids and they are highly conserved between different Salmonella serotypes. The SPIs are located adjacent to tRNA genes (Marcus et al., 2000; Schmidt and Hensel, 2004).

A total of 21 SPIs, namely, SPI-1 to SPI-21 have been identified from *Salmonella*, although the major SPIs include SPI-1, SPI-2, SPI-3, SPI-4 and SPI-5. The SPI-1 and SPI-2 genes are the most extensively studied than other SPIs in the group, and they function to code for proteins forming the type three secretion system (TTSS) which enable the transport of *S. enterica* proteins from the bacterial cell directly into the host cells (Schmidt and Hensel, 2004; Rychlik *et al.*, 2009).

Generally speaking, the two large SPIs, namely, SPI-1 and SPI-2, encode for TTSS that have a central role during *Salmonella* pathogenesis, which involves invasion and intracellular accumulation. The SPI-1 is required for the initial stages of salmonellosis, including: the entry of *Salmonella* into non-phagocytic cells by triggering invasion and the penetration of the gastrointestinal epithelium, and also SPI-1 is required for the onset of diarrhoeal symptoms during localised gastrointestinal infections (Galan, 2001; Schmidt and Hensel, 2004).

The SPI-1-associated proteins include the effector proteins such as Sop (SopA–E); proteins associated with invasion, SipA and InvA; translocon assembly protein including: SipD and flagella associated

proteins, FlgK, FljB and FlgL. On the other hand, the SPI-2 is required for later stages of the infection, including: systemic spread, proliferation and the colonisation within host organs. The role of SPI-2 for survival and replication in host phagocytes appears to be essential for pathogenesis. So, pathogenesis of S. enterica is facilitated by a TTSS encoded by genes of SPI-2. The SPI-2-associated proteins, SsaR and SifA, are associated with survival and replication within the host cells (Figueira and Holden, 2012; Zou et al., 2012).

In addition, there are virulence-associated plasmids that have the spv operon, which consists of five genes, namely, spvRABCD, associated with *Salmonella* survival and growth in macrophages (Rychlík *et al.*, 2006). Type three secretion systems (TTSS) are specialized organelles of Gram-negative bacterial pathogens (Schmidt and Hensel, 2004). TTSS is a needle shaped structure that spans the inner and outer membranes of the bacterial envelope and secretes translocon (translocation channel) and effector proteins (Mueller *et al.*, 2008). Translocon proteins allow entry of effector proteins to the host cell, by either forming pores in the host cell membrane or in some cases act as a connecting channel between the bacterium and the host cell membrane (Frankel *et al.*, 1998; Mueller *et al.*, 2008).

These effectors proteins control a variety of host cell processes in order to successfully invade epithelial cells and to establish host cellular conducive environment permissive for pathogen replication. Type three secretion systems play a vital role in the *Salmonella*-host interaction. *Salmonella* serotypes possess two types of TTSS, namely, TTSS-1 and TTSS-2, which are encoded in distinct regions of the *Salmonella* chromosome (Hansen-Wester and Hensel, 2001). TTSS-1 is expressed when *Salmonella* are moving along the intestinal lumen before it is first encountered with the host cells, and therefore, it is required for initiating intestinal inflammation (Wallis and Galyov, 2000; Hapfelmeier and Hard, 2005).

TTSS-1 triggers invasion of gut epithelial cells enhances colonization of the lamina propria and spread of *Salmonella* to systemic sites. Upon entry into the host intestinal epithelium, *S. enterica* inhabits a vacuolar compartment of the host cells known as macrophages and dendritic cells. This process requires the TTSS-2, which speed up the maturation of the *Salmonella*-containing vacuole (SCV). The TTSS-2 also help to prevent oxidative killing and facilitates systemic spread of the infection (Kuhle and Hensel, 2004; Cheminay *et al.*, 2005).

2.6 Diagnosis

The detection of *Salmonella* in foods is problematic due to presence of fewer no.of organisms, together with larger no.of competing microflora and also due to injured organisms by different food processing methods (Prusak-Sochaczewski, **E. and Luong, J.H.T. 1989**). The conventional culture method, which is routinely used for isolation of *Salmonella* is time consuming, laborious and may not be suitable for viable but non culturable (VBNC) state of the organisms (Bennett, A.R., *et.,al.* 1998). PCR is rapid, specific and sensitive method for the detection of food borne pathogens (Olsen, J.E., *et,.al.* 1991). The increase in the frequency of the outbreaks and the no.of cases has prompted public health officials for accurate detection within few hours. The conventional isolation procedure involves pre enrichment in Buffered peptone water (BPW) for isolation of *S.enteritidis* at 370C for 16h to recover stressed cells (Josefsen, M.H., *et,.al.*2007) and selective enrichment in Rapp port vassilidias broth and tetrathionate broth at 420C for 24h The most commonly used selective enrichment for isolation and identification of *S.enteritidis* are Rapaport Vassilidias soya broth, Selenite cystene broth and Tetrathionate broth (Soumet, C., *et,al.* 1999). Then streaked on selective agar like BGA, XLD, HEA, BSA at 370C for 24h. *Salmonella* will give black centered colonies.

2.7 Prevention and control of (NTS)

In many urban canters, eating and drinking in public establishments, such as Hotels, Restaurants, and Snack bars is a common practice in many countries. These establishments prepare, handle, and serve of food and drink large quantities to large groups people within a short period of time implying a possible risk of infections if sanitary and hygienic norms are not strictly followed. The world health status review indicates that the health problem of developing nations is mainly linked to inadequate sanitation (Kumie et al., 2002).

Better education of food industry workers in basic food safety and restaurant inspection procedures may prevent cross-contamination. Food handling errors can lead to outbreaks. Improvements in farm animal hygiene, in slaughter plant practices, and in vegetable and fruit harvesting and packing operations may help prevent salmonellosis caused by contaminated foods. Pasteurization of milk and treatment municipal supplies highly effective prevention measures that have been in place for decades. Wider use of pasteurized egg and nursing homes is restaurants. hospitals, an important measure. In the future, irradiation or other treatments may greatly reduce contamination of raw meat (CDC, 2008).

Strategies for reducing foodborne illness require a comprehensive farm-to-table approach, while Salmonella contamination from food handlers has been shown to make a significant contribution to human foodborne illness in several developing countries (Catherine et al., 2001). Non-typhoidal S. enterica infections are a major public health problem world-wide and reduction of these diseases serious presents and challenging problem. animal of different serovars have several reservoirs. Large number S.enterica cause gastroenteritis in humans probably makes vaccines very difficult to realize and/or use commercially. The incidence of non-typhoidal salmonellosis continues to rise along with rates of emergence of antibiotic resistant strains and increased centralization of food production. Thus, it is important to monitor every step of food production, from handling of raw products to preparation of finished foods. The prudent use of antimicrobial agents in both humans and animals is necessary to minimize the further emergence of antibiotic resistant strains (Getenet., 2008).

Furthermore, in order to control *Salmonella* infection, an individual should cook foods thoroughly, pasteurize milk and dairy products; avoid consumption of unpasteurized products, prevent cross-contamination of heat-treated foods, avoid undercooked or raw eggs, store heat-treated foods at less than 4°C or greater than 60°C to prevent growth, reduce carriage of livestock by vaccinating or dosing with antibiotics or probiotics, exclude infected or carrier-status individuals from handling food, control rodents and insects and dispose of sewage in a sanitary manner (Buncic, 2006).

2.8 Non Typhoid salmonella in poultry and dairy products of Ethiopia

2.8.1 Non typhoid salmonella in dairy product and raw cow milk

According to (Tesfaw., et al. 2013) the prevalence and antimicrobial resistance of Salmonella isolates from dairy products in Addis Ababa, overall 1.6% (6 of 384) Salmonella prevalence was detected. Salmonella was detected from cheese, butter, and milk with prevalence of 3(3.1%), 1(1.04%), and 2 (2.1%), respectively. However, there was no statistical significant difference in prevalence of

Salmonella among the different dairy samples. Prevalence of Salmonella detected from cheese in this study was in agreement with the work of Zewdu (2004) who reported Salmonella from cheese with prevalence of 2.1% in his previous study of Salmonella organisms in Addis Ababa. Salmonella was detected from milk with prevalence of 2.1%. In Ethiopia, despite attempts to study prevalence of Salmonella mainly in poultry and beef, the status in milk and milk products is still unknown. However, studies made elsewhere indicated that milk and milk products are important source of Salmonella particularly among those raw consumers (WHO, 1988; Jay, 2000). Ubiquitous nature of Salmonella, unhygienic condition prevailing at the farm levels and food handlers, and habit of consuming milk and milk products in raw suggest that milk and milk products can plays great roles as source of Salmonella organisms in Ethiopia. Therefore, even if the study indicated low prevalence of Salmonella in dairy products, it is a potential hazard for Salmonella infection through consumption of dairy products; which is especially important in Ethiopia in general and Addis Ababa in particular where dairy products are in most of the time consumed without appropriate cooking practices. In Ethiopia, there is a habit of smoking of utensils which are used for preparation of yogurt. This was scientifically justified by Mogessie and Fekadu (1993) and Lemma (2004) that smoking reduces the undesirable microbial contamination which enhances the fate of fermentation and passing the smoke flavor to the milk; this might also contribute for absence of detection of Salmonella from yogurt samples. However, the prevalence of Salmonella in yogurt in this study cannot enable to disregard yogurt as a vehicle for salmonella infection. This higher prevalence is a concern to the dairy farms that provide milk and milk products to the community since cross contamination from infected individuals could be a potential source of food borne infections. Resistance for two or more of antimicrobials (83.3%) which was observed in this study was higher than other studies conducted in Ethiopia [Molla W,et al., 2006, Zewdu E, and Cornelius P 2009, Alemayehu D, et al, 2003, Sibhat B, 2009].

2.8.2 Non-typhoidal Salmonella in poultry products

Foods of animal origin, especially poultry and poultry products, including eggs, have been consistently implicated in sporadic cases and outbreaks of human salmonellosis, and chicken products are widely acknowledged to be a significant reservoir for *Salmonella* (Panisello et al., 2000). In Ethiopia, there is no *Salmonella* serotype and antimicrobial resistance surveillance and monitoring system, therefore the available information are fragmented and made available through individual publications. One study, conducted on chicken and different chicken products in Ethiopia indicated the presence of different serotypes of *Salmonella* (Molla *et al.*, 2003). In that study out of the total 80 *Salmonella* isolates, 8 different serotypes were identified of which *Salmonella braenderup* was the most frequent followed by *S. typhimurium var. copenhagen*, *Salmonella anatum*, *Salmonella kottbus* and *Salmonella typhimurium*. Other serotypes isolated include *Salmonella bovismorbificans*, *Salmonella hadar* and *Salmonella infantis*. *S. braenderup*, *S. anatum* and *Salmonella newport* appear to be the major *Salmonella* serotypes associated with chicken meat and chicken meat products around Addis Ababa (Zewdu, 2008).

2.9 Antibiotic Resistance Non Typhoid Salmonella

2.9.1 Global trends in antimicrobial resistance patterns

The use, over-use and miss-use of antimicrobials in production animals act as a potential risk factor (selective pressure) for the occurrence and the emergence of antimicrobial resistance in public health important pathogens. So, the effect of antimicrobial use in food animals on the development of resistance in pathogenic bacteria has been a subject of prolonged debates worldwide (Lathers, 2002;

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Callie *et al.*, 2012). The increased criticism of agricultural usage of antimicrobials has reached a climax, particularly in the United States, European countries and elsewhere, coinciding with the antimicrobial resistance crisis in human medicine (Sharma *et al.*, 2005). Occurrence of antimicrobial resistance to different classes of antimicrobials has emerged, and this has led to emergence of antimicrobial resistant bacteria, which are becoming a serious public health menace (Nweneka *et al.*, 2009; Rodriguez-Rojas *et al.*, 2013).

As a result of the intensive use of antimicrobials in food animal production, food animal products such as meat, eggs and milk are frequently contaminated with antimicrobial resistant foodborne pathogens such as *Salmonella* spp. and *E. coli* (Cosgrove and Carmeli, 2003; Hammerum and Heuer, 2009). Of more direct relevance to public health is the potential of resistant pathogens in food animals finding their way into humans (Howard *et al.*, 2001).

Hence, humans can be colonised with the antimicrobial resistant pathogens of animal origin, and because of resistance to commonly used antimicrobials, these bacteria may cause infections for which limited therapeutic options are available. This may lead to treatment failure in both humans and animals (Howard *et al.*, 2001; Gilbert, 2012). Furthermore, the resistant bacteria of animal origin may potentially act as a source of antimicrobial resistance genes for other pathogenic bacteria in the microbial ecosystem. Thus, the intensive use of antimicrobials in food animal production may add to the burden of antimicrobial resistance in humans (Hur *et al.*, 2012; Zhu *et al.*, 2013).

2.9.2 Resistance patterns in Ethiopia

Antimicrobial resistance is a global problem in general (Acha and Szyfres 2001), but it might be more severe in Ethiopia where there is lack of antimicrobial resistance assessments of *Salmonella* and lack of rigorous regulations but there is easy access of antimicrobials for purchase of people without prescription and incomplete treatment courses as the result of patient noncompliance (Beyene *et al.*, 2011). There have been studies conducted in Ethiopia on salmonellosis which suggest an increase in the antimicrobial resistance of *Salmonella* to commonly used antimicrobials in both the public health and veterinary sectors (Mache, 2002; Molla *et al.*, 2003; Alemayehu *et al.*, 2004; Argaw *et al.*, 2007; Beyene *et al.*, 2011; Sibhat *et al.*, 2011).

A study, Beyene *et al.* (2011) detected multiple drug resistant *Salmonella* organisms in their study on aetiology of febrile and diarrheic illness in Ethiopian children focusing on *Salmonella*. According to Mache (2002), *Salmonella* was one of the major causes of diarrhoea in humans. This together with tradition of raw meat consumption and indiscriminate use of antimicrobials signifies the importance of salmonellosis in the country. In a study conducted by Behailu and Mogessie in 2010, about 70 % of the isolates had varying resistance to the tested antibiotics. Multiple drug resistance was observed in over 30 % of the *Salmonella* isolates. High proportion of *Salmonella* isolates developed resistance to the commonly prescribed antimicrobials and this may be a considerable risk in the treatment of clinical cases (Addis *et al.*, 2011). In addition, according to (Sibhat *et al.*, 2011) out of the 87 isolates 18 (20.7 %) *Salmonella* serovars consisting of Newport (n = 14), Anatum (n = 3) and Eastbourne (n = 1) were resistant to two or more antimicrobials. Among the antimicrobial resistant *Salmonella* serovars, *S.* Newport was multidrug resistant (15.6 %) and exhibited resistance to streptomycin, sulphisoxazole and tetracycline.

2.9.3 Public Health Aspects of Multidrug-Resistant NT Salmonella

Antimicrobial drug resistance in *Salmonella* varies by serotype; hence serotype information is fundamental to understanding the epidemiology of *Salmonella*, including drug-resistant strains (WHO, 2014). Moreover, isolated multidrug-resistant (MDR) *Salmonella* strains have been found to be of many serotypes including Agona, Anatum, Choleraesuis, Derby, Dublin, Heidelberg, Kentucky, Newport, Pullorum, Schwarzengrund, Senftenberg, Typhimurium, and Uganda. Therefore, the degree and frequency of MDR in *Salmonella* present in humans and food animals, is a major concern (Ibarra, J. A., et al 2009, Hur, J., C.et.al., 2012).

Antimicrobial resistance monitoring programs have been initiated globally. In the U.S., the Centers for Disease Control and Prevention (CDC), the Food and Drug Administration (FDA), and the U.S. Department of Agriculture (USDA) established the National Antimicrobial Resistance Monitoring System (NARMS) to monitor changes in antimicrobial susceptibilities of zoonotic pathogens from human and animal clinical specimens, from healthy farm animals, and from raw product of food-producing animals at slaughter and processing (FDA., 2015, and Hur, J., C.et.al., 2012).

In recent years, the increasing prevalence of multi-drug resistant (MDR) *Salmonella* to clinically important antimicrobial agents such as fluoroquinolones and third-generation cephalosporins has become an emerging public health problem worldwide (Hur, J., C.et.al.,2012, Su, L. H., 2004). Furthermore, one major concern to public health has been the emergence of *Salmonella* Definitive Type 104 (DT104), which was first identified in the United Kingdom in1984, and later identified in other parts of the world. This phage type commonly exhibits multi-drug resistance to five antimicrobial agents: ampicillin, chloramphenicol, streptomycin, sulfamethoxazole, and tetracycline (R-type ACSSuT) (Hur, J., C., et. al. 2012, Su, L. H., 2004).

For non typhoidal *Salmonella*, this multidrug-resistance phenotype (ACSSuT) represents five classes according to Clinical & Laboratory Standards Institute (CLSI). Another similar pattern of resistance to at least ASSuT (but not chloramphenicol) has emerged in recent years. An additional important MDR phenotype in *Salmonella* includes resistance to at least ampicillin, chloramphenicol, streptomycin, sulfonamide, tetracycline, amoxicillin-clavulanic acid, and ceftriaxone (ACSSuTAuCx); these agents represent seven CLSI classes (Centers for Disease Control and Prevention. 2015, 2013 NARMS) Annual Human Isolates Report.

Because antimicrobial resistant bacteria may be transferred to humans through the food chain, selection of novel antimicrobial resistance mechanisms in *Salmonella* in animals, which specific resistance to antibiotics used in humans is troubling. Efforts that include further implementation of hazard analysis of critical control point programs in food production are needed to reduce the incidence of *Salmonella* in food producing animals and consequently in humans (Chen, S., 2004). Preventing the widespread dissemination of MDR *Salmonella* requires sustained effort, commitment, and collaboration among many groups in the public and private sectors, and involvement of the general public. It also requires support and leadership from the federal government and a willingness to address complex and sometimes controversial scientific, medical, and economic issues (Hur, J., C. Jawale, and J. Hwa Lee. 2012).

2.9.4 Global efforts to combat antimicrobial resistance

Antimicrobial resistance is a complex problem to tackle and is driven by many interconnected factors. As such, antimicrobial resistance is occurring everywhere in the globe to the extent of compromising our ability to treat infectious diseases (Aminov and Mackie, 2007; Wright, 2007). Therefore, coordinated actions are required to minimize the emergence and spread of antimicrobial resistance. World Health Organization (WHO), is working closely with the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) in a One Health approach to promote optimal use of antibiotics in both humans and animals. The sixty-eight World Health Assembly in May 2015, the World Health Assembly endorsed a global action plan to tackle antimicrobial resistance. The goal of the global action plan is to ensure the continuity of successful treatment and prevention of infectious diseases with effective and safe medicines (WHO, 2001).

A number of issues have been raised to help in containing antimicrobial resistance, including, improving awareness and understanding of antimicrobial resistance, strengthening knowledge through surveillance and research, reducing the incidence of infection, optimizing the use of antimicrobial agents and developing the economic case for sustainable investment that takes into account the needs of all countries, and the need for increasing investment in new medicines, diagnostic tools and vaccines (WHO, 2000). In recognition of such efforts, international partners such as the WHO, FAO and World Organization for animal health and the national partners are engaged in set of activities, such as, improving national awareness and understanding of antimicrobial resistance through public communication programmes that target the different audiences in human health, animal health and agricultural practices (WHO, 2001).

3. Conclusion and recommendation

Globally, more than 93 million cases of gastroenteritis are caused by non typhoidal *Salmonella* with 155,000 deaths each year. Of these cases, 80.3 million cases were estimated to be food borne. Non-typhoidals fever, which is caused mainly by *Salmonella typhimurium and Salmonella enteritidis*, continues to be a major problem in developing countries. Gastroenteritis is the most common manifestation of *Salmonella* infection worldwide, followed by bacteraemia and enteric fever. *Salmonella* make up a large genus of gram-negative bacilli within the family *Enterobacteriaceae* and it constitute a genus of more than 2300 serotypes that are highly adapted for growth in both humans and animals and that cause a wide spectrum of disease. The main mode of transmission is from food products contaminated with animal products or waste most commonly eggs and poultry but also undercooked meat, unpasteurized dairy products, seafood, and fresh produced. *S. enteritidis* associated with chicken eggs is emerging as a major cause of foodborne disease. The use, over-use and miss-use of antimicrobials in production animals act as a potential risk factor (selective pressure) for the occurrence and the emergence of antimicrobial resistance in public health important pathogens. Based on the above conclusion I tried to forward this recommendation:-

- The veterinarian should be: give awareness for the farmers owners to not use the drugs in food products of animal's origins and feed of animals
- The abattoir personnel should be: gained training about food safety issue and hygienic practiced specially on pathogenic bacteria.
- The consumer should be: avoid cross contamination of ready to eat food product
- The government should be: motivate the VPH professionals to do the research on Antibacterial resistance issue and hygienic practice in the abattoir and dairy farm.

The government should Fulfilling the National laboratories material and facility for the diagnosis of resistance developed bacterial agents and increasing the veterinary laboratory technologist profession nationally to know the detail disease problem of the country and strength the link between different health disciplines and applying of the (One-Health) concept.

REFERANCE

- **1.** Abebe M, Tafese B, Adane H (2014). Antimicrobial resistance of *Salmonella* serovars isolated from food of bovine origin in selected Woredas of Tigray, Ethiopia. World J. Med. Sci. 11(3):342-347.
- **2.** Alemayehu D, Molla B, Muckle A (2004). Prevalence and antimicrobial resistance pattern of *Salmonella* isolates from apparently healthy slaughtered cattle in Ethiopia. Trop. Anim. Health Prod. 35:309-319.
- **3.** Antunes P, Réu C, Sousa JC, Peixe L, Pestana N. Incidence of Salmonella from poultry products and their susceptibility to antimicrobial agents. Int J Food Microbiol 2003; 82:97–103.
- **4.** Argaw K, Molla B, Muckle A, Cole L, Wilkie E, Poppe C, Kleer J, Hilderbrandt G (2007). The characterization of *Salmonella* serovars isolated from apparently healthy slaughtered pigs at Addis Ababa abattoir, Ethiopia. Prev. Vet. Med. 82:252-261.
- **5.** Bean, N.H., Griffin, P.M., Goulding, J.S. and Ivey, L.B. (1990). Food borne disease outbreaks, 5 years summery, 1983-1987. *J. Food Prot.*, 53: 711-728.
- **6.** Beyene G, Nasir S, Asrat D, Mengistu Y, Engers H, Wain J (2011). Multidrug resistant *Salmonella* Concord is a major cause of salmonellosis in children in Ethiopia. J. Infect. Dev. Ctries. 5:23-33.
- **7.** Bennett, A.R., Greenwood, D., Tennant, C., Banks, J.G. and Betts, R.P. (1998). Rapid and definitive detection of *Salmonella* in foods by PCR. *Lett. Appl. Microbiol.*, 26:437-441.
- **8.** Boonmar, S., Bangtrakulnonth, A., Pornrunangwong, S., Terajima, J., Watanabe, H., Kaneko, K.I. and Ogawa, M. (1998). Epidemiological analysis of *Salmonella*
- **9.** CDC. (2008)d. Outbreak of multidrug-resistant *Salmonella* enterica serotype Newport infections associated with consumption of unpasteurized Mexican-style aged cheese--Illinois, March 2006-April 2007, *MMWR*, Vol.57, No.16, (April 2008), pp.432-435, ISSN 0149-2195
- **10.** CDC. (2010) a. Investigation Update: Multistate Outbreak of Human *Salmonella* Enteritidis Infections Associated with Shell Eggs. In: *Salmonella Outbreaks*, 20.7.2011, Available from: http://www.cdc.gov/salmonella/enteritidis/index.html
- **11.** CDC. Centers for Diseases Control and Prevention. Salmonella: annual summary 2005. Atlanta, Georgia: US Department of Health and Human Services; 2007c [cited 2009 jul 14]. Available from: http://www.cdc.gov/ncidod/dbmd/phlisdata/salmtab/2005/SalmonellaAnnual Summary 2005.pdf.
- **12.** Centers for Disease Control and Prevention (2008). Outbreak of salmonella serotype Saint paul infections associated with multiple raw produce items. Retrieved from CDC Web site: http://www.cdc.gov/safewater (accessed on 08/08/2012).
- **13.** Centers for Disease Control and Prevention. 2015. 2013 NARMS Annual Human Isolates Report. http://www.cdc.gov/narms/pdf/2013-annual-report-narms 508c.pdf. Accessed 30 November 2015.
- **14.** CDC, (2003). Outbreaks of *S. Enteritidis* infections associated with eating raw or under cooked shell eggs, United States, 1999- 2001. *MMWR*., 51: 1149-1152.

15. Chen, S., S. Zhao, D. G. White, C. M. Schroeder, R. Lu, H. Yang, P. F. McDermott, S. Ayers, and J. Meng. 2004. Characterization of multiple-antimicrobial-resistant *Salmonella* serovars isolated from retail meats. *Appl. Environ. Microbio.* 70(1):1-7.

- **16.** Dominguez, M., Jourdan-Da Silva, N., Vaillant, V., Pihier, N., Kermin, C., Weill, F.X., Delmas, G., Kerouanton, A., Brisabois, A. & De Valk, H. (2009). Outbreak of *Salmonella* enterica serotype Montevideo infections in France linked to consumption of cheese made from raw milk, *Foodborne Pathogens and Disease*, Vol.6, No.1, (January-February 2009), pp. 121-128. ISSN 1535-3141
- **17.** D'Aoust, J.Y. (1997). *Salmonella spp*, p. In Doyle MP, Beurhat, L.R. and Mantville, T.J. (Eds). Food microbiology. fundamentals and frontiers. *ASM press, Washington D.C.*, 129 158.
- **18.** Epidemiological analysis of *Salmonella enteritidis* isolates from humans and broiler chickens in Thailand by phage typing and pulsed-field gel electrophoresis. *J. Clinical Microbiol.*, 36: 971-974.
- **19.** El-Gazzar, F.E. and Marth, E.H. (1992). *Salmonellae*, Salmonellosis, and dairy foods: A review. *J. Dairy Sci.*, 75: 2327-2343.
- **20.** Evans, M.R., Tromans, J.P., Dexter, E.L.S., Riebeiro, C.D. and Gardner, D. (1996). Consecutive *Salmonella* outbreaks traced to the same bakery. *Epidemiol. Infect.*, 116: 161-167.
- **21.** Fajardo, T.A., Anantheswaran, R.C., Puri, V.M. and Knabel, S.J. (1994). Penetration of *Salmonella enteritidis* into eggs subjected to rapid cooling. *J. Food. Prot.*, 58: 473-477.
- **22.** Food and Drug Administration (FDA). 2015. An overview of NARMS. Available at: http://www.fda.gov/AnimalVeterinary/Safety Health/Antimicrobial Resistance/Natio nal Antimicrobial Resistance Monitoring System/ucm453363.htm. Accessed 30 March 2016.
- **23.** Foley, S. L., and A. M. Lynne. 2008. Food animal-associated *Salmonella* challenges: Pathogenicity and antimicrobial resistance. *J. Anim. Sci.* 86:e173-e187.
- **24.** Fuaci, K. L. and Jameson, H. L. (2005): *Harrison's* Principles of Internal Medicine. 16th ed. Kasper, D. L., Fauci, A. S., Longo, D. L., Braunwald, E., Hauser, S. R. and Jameson, J. L.(eds), McGraw-Hill, Pp. 897-902.
- **25.** Gantois, I., Ducatelle, R., Pasmans, F., Haesebrouck, F., Gast, R., Humphrey, T.J. and Van Immerseel, F. (2009). Mechanisms of egg contamination by *Salmonella enteritidis*. FEMS *Microbiol. Rev.*, 718-738.
- **26.** Gast, R.K., and Beard, C.W. (1990). Production of *Salmonella enteritidis* contaminated eggs by experimentally infected hens. *Avian. Dis.*, 34: 438-446.
- **27.** Gast, R.K. and Holt, P.S. (2000). Deposition of phage type 4 and 13a *Salmonella enteritidis* strains in the yolk and albumen of eggs laid by experimentally infected hens. *Avian Dis.*, 44: 706-710.
- **28.** Gast, R.K., Petter, G. and Holt, P.S. (2002). Chracteristics of *Salmonella enteritidis* contamination in eggs after oral, aerosol, and intravenous inoculation of laying hens. *Avian Dis.*, 46: 629-635.
- **29.** Gibson, D.L. (2000). *Salmonella enteritidis* thin aggregative fimbriae and the extracellular matrix. Ph.D Thesis, University of Victoria. Massive outbreak of antimicrobial resistant salmonellosis traced to pasteurized milk. *J. Am. Med. Assoc.*, 258: 3269-3274.
- **30.** Getenet, B. (2008): Phenotypic and molecular characterizations of *Salmonella* species in Ethiopia. PhD Thesis, Addis Ababa University, Faculty of Medicine, Addis Ababa, Ethiopia.
- **31.** Gibson, D.L. (2000). *Salmonella enteritidis* thin aggregative fimbriae and the extracellular matrix. Ph.D Thesis, University of Victoria.
- **32.** Graham JP, Boland JJ, Silbergeld E (2007). Growth promoting Kemal *et al.*, 2255 antibiotics in Volume 3, Issue XII, December 2020 | 386

food animal production: an economic analysis. Public Health Rep. 122(1):79-87.

- **33.** Hassanien, R., Hassan Ali, S.F., El-Malek, A.M.A., Moemen., Mohamed, A. and Elsayh, K.I. (2011). Detection and identification of *Salmonella* species in minced beef and chicken meats by using multiplex PCR in assiut city. *Vet. World.*, 4(1): 5-11.
- **34.** Jayaroo BM, Henning DR, (2001). Prevalence of food borne pathogens in bulk tank milk. J. Dairy Sci. 84(10): 2157–2162.
- **35.** Haeschen, J. (2000). Pathogenic bacteria in raw milk-Situation and significance. Symposium on bacteriological quality of raw milk, Wolf passing, Austria **23**, 60-64.
- **36.** Headrick, M. L., Timbo, B., Klontz, K. C. and Werner, S. B. (2001). Profile of raw milk consumers in California. Journal of Public Health **112**, 418-422.
- **37.** Hennessy, T.W., Hedberg, C.W., Slutssker, L., White, K.E., Besser-wiek, J., Moen, M.E., Feldman, J., Coleman, W.W., MacDonald, K.L. and Osterholm, M.T. (1996). A national outbreak of *S. enteritidis* infection from ice cream. *N. Engl. J. Med.*, 334: 1281-1286.
- **38.** Hitti W, Wolff M (2005). Two cases of multidrug-resistant *Nocardia farcinica* infection in immunosuppressed patients and implications for empiric therapy. Eur. J. Clin. Microbiol. Infect. Dis. 24:142-144.
- **39.** Hogue, A.T., Ebel, E.D., Thomas, L.A., Schlosser, W., Bufano, N. and Ferris, K. (1997). Surveys of *Salmonella enteritidis* in unpasteurized liquid egg and spent hens at slaughter. *J. Food Prot.*, 60: 1194-200.
- **40.** Hoop, R.K. and Pospischil, A. (1993). Bacteriological, serological, histological and immune-histochemical findings in laying hens with naturally acquired *Salmonella enteritidis* phage type 4 infections. *Vet. Rec.*, 133: 391-393.
- **41.** Hogue, A.T., Ebel, E.D., Thomas, L.A., Schlosser, W., Bufano, N. and Ferris, K. (1997). Surveys of *Salmonella enteritidis* in unpasteurized liquid egg and spent hens at slaughter. *J. Food Prot.*, 60: 1194-200.
- **42.** Hur, J., C. Jawale, and J. Hwa Lee. 2012. Antimicrobial resistance of *Salmonella* isolated from food animals: A review. *Food Res. Int.* 45:819-830.
- **43.** Ibarra, J. A., and O. Steele-Mortimer. 2009. *Salmonella* the ultimate insider. *Salmonella* virulence factors that modulate intracellular survival. *Cell Microbiol*. 11:1579-1586.
- **44.** Jay, J.M. (2000). Food borne gastroenteritis caused by *Salmonella* and *shigella*. *Modern Food Microbiol*. 6: 511-528.
- **45.** Josefsen, M.H., Krause, M., Hansen, F. and Hoorfar, J. (2007). Optimization of a 12- hour TaqMan PCR- based method for detection of *Salmonella* bacteria in meat. *Appl. Environ. Microbiol.*, 73: 3040- 3048.
- **46.** Lecos, C. (1986). Of microbes and milk: America's worst *Salmonella* outbreak. *Dairy and Food Sanitation*. 6: 136-140.
- **47.** Langridge, G., Nair, S. and Wain, J. (2008): Invasive Salmonellosis in Humans. In Böck, R. C. I. A., Kaper, J. B., Neidhardt, F. C., Nyström, T., Rudd, K. E. and C. L. Squires (eds): *EcoSal-Escherichia coli* and *Salmonella*: cellular and molecular biology, ASM Press, Washington, D.C. Available from: http://www.ecosal.org/.
- **48.** Liyuwork T, Biruhalem T, Sefinew A, Haile A, Zufan S, Haileleul N (2013). Prevalence and antimicrobial resistance profile of *Salmonella* isolates from dairy products in Addis Ababa, Ethiopia. Afr. J. Microbiol. Res. 7(43):5046-5050.
- **49.** Mache A (2002). *Salmonella* serogroups and their antimicrobials resistance patterns isolated from diarrheal stools of paediatric outpatient in Jimma Hospital and Jimma Health Center, South West Ethiopia. Ethiop. J. Health Sci. 12:37-46.

50. Mastroeni, P. (2006): Mechanisms of immunity in Salmonella infection, pp. 207-254. In P. Mastroeni, and D. Maskell (Eds): Salmonella infections: Clinical, Immunological and Molecular aspects, Cambridge University press, Cambridge.

- **51.** McClelland, M., Sanderson, K. E., Spieth, J., Clifton, S. W., Latreille, P., Courtney, L., Porwollik, S., Ali, J., Dante, M., Du, F., Hou, S., Layman, D., Leonard, S., Nguyen, C., Scott, K., Holmes, A., Grewal, N., Mulvaney, E., Ryan, E., Sun, H., Florea, L., Miller, W., Stoneking, T., Nhan, M., Waterston, R., and Wilson, R. K. (2001): Complete genome sequence of Salmonella enterica serovar Typhimurium LT2. Nature 413, 852-6.
- **52.** Mengistu G, Mulugeta G, Lema T, Aseffa A (2014). Prevalence and antimicrobial susceptibility patterns of *Salmonella* serovars and *Shigella* species. J. Microb. Biochem. Technol. 6(S2):S2-006.
- **53.** Molla B, Mesfin A, Alemayehu D (2003). Multiple antimocrobial-resistant *Salmonella* serotypes isolated from chicken carcass and giblets in Debre Zeit and Adis Ababa, Ethiopia. Ethiop. J. Health Dev. 17(2):131-149.
- **54.** Newell, D. G., M. Koopmans, L. Verhoef, E. Duizer, A. Aidara-Kane, H. Sprong, M. Opsteegh, M. Langelaar, J. Threfall, F. Scheutz, J. v. der Giessen, and H. Kruse. 2010. Foodborne diseases -- The challenges of 20 years ago still persist while new ones continue to emerge. *Int. J. Food Microbiol.* 139:S3-S15.
- **55.** Nusrat, Y., Jafar, K., Noureen, S., Zia, U. I., Rashid, A. K. and Noor, U. S. (2012). Bacteriological study of food in the Tanzania. African Journal of Biotechnology **11**(39), 9445-9451.
- **56.** Olsen, J.E., Aabo, S., Nielsen, E.O. and Nielsen, B.B. (1991). Isolation of a *Salmonella* specific DNA hybridization probe. *APMIS.*, 99: 114-120.
- **57.** Olsvik, O., Sørum, H., Birkness, K., Wachsmuth, K., Fjølstad, M., Lassen, J., Fossum, K. and Feeley, J. C. (1985): Plasmid characterization of *Salmonella* Typhimurium transmitted from animals to humans. *J. Clin. Microbiol.*, **22**: 336-338.
- **58.** Parry, C. M. (2003): Antimicrobial drug resistance in Salmonella enterica. Curr Opin Infec Dis 16, 467-72.
- **59.** Prusak-Sochaczewski, E. and Luong, J.H.T. (1989). An improved ELISA method for the detection of *Salmonella* typhimurium. *J. Appl. Bacteriol.*, 66: 127-135.
- **60.** Pui, C. F., Wong, W. C., Chai, L. C., Tunung, R., Jeyaletchumi, P., Noor Hidayah, M. S., Ubong, A., Farinazleen, M. G., Cheah, Y. K. and Son, R. (2011): Review Article *Salmonella*: A foodborne pathogen. *Int. Food Res. J.*, **18**: 465-473.
- **61.** Ryan, C.A., Nickels, M.K., Hargeyy-bean, N.T., Potter, M.E., Endo, T., Mayer, L. Langkop, C.W., Gibson, C., McDonald, R.C., Kenny, R.T., Buhr, N.D., McDonnel, P.J., Martin, R.J., Cohen, M.L. and Blake, P.A. (1987).
- **62.** Rowe, B., Begg, N.T., Hutchison, D.N., Dawkin, H.C., Gilbert, R.J., Jacob, M., Hales, B.M., Rae, F.A. and Jepson, M. (1987). *Salmonella* eailing infections associated with consumption of infant dried milk. *Lancet.*, ii: 900-903.
- **63.** Rogelj, R. M. (2003). Trouble shooting high bacteria counts in farm milk. Journal of Microbiology **98**, 35-39.
- **64.** Salmon, D. E. and Smith, T. (1886): The bacterium of swine plague. Am. Month. Microbiol. *Salmonella* nomenclature. *J Clin Microbiol.*, **38**: 2465-2467.
- **65.** Shea KM (2003). Antibiotic Resistance: What is the Impact of Agricultural Uses of Antibiotics on Children's Health? Pediatrics 112:253-258.
- **66.** Synnot, M.B., Brindley, M., Gray, J. and Dawson, J.K. (1998). An outbreak of *Salmonella* Volume 3, Issue XII, December 2020 | 388

agona infection associated with precooked turkey meat. *PHLS*, *Commun. Dis. Public Health.*, 1: 176-179.

- **67.** Stephenson, P., Satchell, F.B., Allen, G. and Andrews, W.H. (1991). Recovery of *Salmonella* from shell eggs. *J. Assoc. Off. Anal. Chem.*, 74: 821-826
- **68.**Soumet, C., Ermel, G., Rose, N., Rose, V., Drouin, P., Salvat, G. and Colin, P. (1999). Identification by a multiplex-PCR-based assay of *Salmonella Typhimurium* and *Salmonella enteritidis* starins from environment swabs poultry houses. *Lett. Appl. Microbiol.*, 29: 1-6.
- **69.** Su, L. H., C.H. Chiu, C. Chu, and J. T. Ou. 2004. Antimicrobial resistance in Non-typhoid *Salmonella* serotypes: A global challenge. *Clin. Infect. Dis.* 39:546-551.
- **70.** Sibhat B, Molla B, Zerihun A, Muckle A, Cole L, Boerlin P, Wilkie E, Perets A, Mistry K, Gebreyes WA (2011). *Salmonella* Serovars and Antimicrobial Resistance Profiles in Beef Cattle, Slaughterhouse Personnel and Slaughterhouse Environment in Ethiopia. Zoonoses Public Health 58:102-109.
- **71.** Vanhooser, S.L. and Welsh, R.D. (1995). Isolation of *Salmonella* species from ratites. *J. Vet. Diagn. Invest.*, 7: 268-269.
- **72.** Vanhoof R, Gillis P, Stévart O, Boland C, Vandenberg O, Fux F, Collard JM, Bertrand S (2012). Transmission of multiple resistant *Salmonella* Concord from internationally adopted children to their adoptive families and social environment: proposition of guidelines. Eur. J. Clin. Microbiol. Infect. Dis. 31:491-497.
- **73.** Wang, S.J., Yeh, D.B. and Wei, C. (2009). Specific PCR primers for the identification of *Salmonella enteric serovar enteritidis* in chicken related samples. *J. Food and Drug Analysis*. 17(3): 183-189.
- **74.** WHO (1989): Health surveillance and management procedures of food handling workers. Geneva, Pp. 7-36.
- **75.** World Health Organization (WHO). 2013. Integrated surveillance of antimicrobial resistance. Available at: http://apps.who.int/iris/bitstream/10665/91778/1/9789241506311_eng.pdf. Accessed 30 March 2016.7
- **76.** World Helalth Organization (WHO). 2014. Antimicrobial resistance: Global report on surveillance. Available at: http://www.who.int/drugresistance/documents/surveillancereport/en/. Accessed 29 March 2016.
- 77. Yang B, QUD, Zhang X, Shen J, Cui S, Shi Y, XiM, Sheng M, Zhi S, Meng J (2010). Prevalence and characterization of *Salmonella* serovars in retail meats of market place in Shaanxi, China. Int. J. Food Microbiol. 141(1-2):63-72.
- **78.** Zewdu E (2008). Prevalence, distribution and antimicrobial resistance profile of *Salmonella* isolated from food items and personnel in Addis Ababa, Ethiopia. Trop. Anim. Health Prod. 41:241-24.